5 November 1974

MEMORANDUM FOR THE RECORD

SUBJECT: U.S. v. IBM

In my telecon with Dick Irvine of Justice today, I told him that documents #11 and 14 set out in the Cravath letter to Justice of September 4, 1974 and relayed to me by Irvine's letter of October 26 were definitely not Agency. In this connection, I called his attention to the fact that the cover sheet made it quite obvious that Rand had prepared these documents for the Defense Advanced Research Projects Agency (ARPA) and the Council on International Economic Policy (CIEP). In order to obtain the required approvals he sought, I suggested that he contact those two agencies. I told him that the office locations of ARPA and CIEP could be found in the U.S. Government Manual 73/74 at pages 196 and 187 respectfully. I emphasized to him that we would take no further action with respect to these documents but that I would move ahead with the other four which seemed to have been originated by the Agency.

\# 14

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THE EXPECTED IMPACT OF COMPUTERS ON SOVIET ECONOMIC PERFORMANCE

Arthur J. Alexander

A WORKING NOTE
prepared for the
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY/
COUNCIL ON INTERNATIONAL ECONOMIC POLICY

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25th Year
Rand
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PREFACE

This Working Note has been prepared as an input to an interagency study of computer export policy which is being undertaken by the Council on International Economic Policy. The paper is also an integral part of Rand's work on international technology exchange for the Defense Advanced Research Projects Agency.

THE EXPECTED IMPACT OF COMPUTERS ON SOVIET ECONOMIC PERFORMANCE

The driving forces behind the burgeoning Soviet demand for computers have been the increasing inefficiency of the statewide planning system, the falling growth rate of the economy, and the near collapse of growth in total factor productivity. It is analytically convenient, as well as factually correct, to separate Soviet economic problems into the areas suggested above --the economic planning process as distinct from the producing sector of the economy. We shall first concentrate on computers in the planning process, and then turn to a discussion of the operating economy.

COMPUTERS AND THE PLANNING SYSTEM

Soviet political leaders establish the broad outlines and strategy of economic production and development. These directions are given to the State Planning Agency (Gosplan) which works out in detail the amounts going to private and government consumption, military users, investment, foreign trade, and other final users. The most difficult part of the planning process, however, involves the calculation of how the output will be produced --which ministries and enterprises, with what technologies and mix of materials, and with what priorities if the output plans are inconsistent or infeasible. This must be done for the nation as a whole, for each geographical region, for each ministry, down to the enterprise level. Plans must be prepared for 50,000 industrial enterprises and more than a million enterprises of all types. Eighteen thousand products are planned in detail. The number of enterprises and products are growing each year and the problem of integrating the expanding number of details is growing at an even faster rate. A leading cyberneticist, V. Glushkov, has claimed that if planning efficiency did not improve and if present growth rates remained constant, every Soviet adult would be engaged in planning by 1980. At the time of this statement (1966), the number of planners had increased by 50 percent in the preceding five years.

While Glushkov's statement is somewhat self-serving in that his research institute and field of expertise would benefit from the proposed solution to the problem, the statement has been widely quoted in the Soviet Union as being a roughly correct caricature of the problem. In fact, because of the immense size of the planning job, most plans are late, inconsistent, and

nonoptimal. The plans are published well after the beginning of the production period to which they refer, so that enterprises must operate for part of the year without detailed knowledge as to their goals and the resources available to meet them. The list of goods designated for end uses generally cannot be produced with the resources allocated according to the plan. And it would be possible, theoretically, to produce more final output with the available resources.

A large and somewhat grandiose scheme was proposed in the mid-1960s to meet the perceived problems in the planning system. The automated system of planning calculations (ASPR) is a system for working out the national economic plans and supervising plan fulfillment through the use of mathematical economics and computer technology. ASPR includes "constructing of an interrelated system of models of long-, medium-, and short-term national economic development plans; systematizing of plan indicators; determining the necessary information flows and the principles of using the information; developing the mathematical models; and determining the necessary equipment."[1] Gosplan and the Central Mathematical Economics Institute (TsEMI) are the organizations chiefly responsible for the implementation of ASPR. This integrated planning system will require an enormous quantity of computing machinery, information transmission equipment, programming, model building and estimation, and a good deal of basic theoretical work. Despite the fact that perhaps thousands of individuals and several research institutes are involved in its creation, very little of actual output has been produced and the scope of the project has been gradually trimmed back.

Although ASPR is likely to be implemented only in part, computer use, and more generally economic cybernetics, has been growing on a piecemeal basis throughout the planning bureaucracy.[2] Computers may enable the planning agencies to collect and analyze large amounts of data, to manipulate

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[1] "The Creation of an Automated Planning Calculation System--A Nationwide Task," Plannovoye Khozyzystvo, No. 8, August 1972; translated in JPRS, 13 November 1972, pp. 1-2.

[2] Economic cybernetics, as narrowly conceived, is simply mathematical economic models. However, broader and more common usage refers to comprehensive systems of economic planning and management based on mathematical models integrated with computers and large data bases.

complex economic models and estimate their parameters, and to produce and transmit planning goals to economic organizations. The use of computers may provide Soviet planners the ability to produce plans that are somewhat more efficient and timely than is possible by present procedures. But most outside observers, as well as quite a few Soviet economists, believe that the main defects in the economy can be traced to the system of incentives and to the basic structuring of economic life. For example, the parameters of a mathematical model of the economy are usually assumed to be determined by the technology of production processes. However, the observed processes are the outcomes of many distorting forces -- the measured parameters include a mix of technology, "quasi" price incentives, inefficiency, perversity, and chicanery. Construction and implementation of a plan based on such inputs will include all of the nontechnological elements. However, <u>it is unlikely that even this nonoptimal plan could actually be implemented.</u> The problems run deeper. Typical of many comments are the following quotations:

> It is widely known that the compilation of optimal schemes of freight shipment can yield a quite tangible saving. This is not a complicated task. Many articles and books have been written and not a few dissertations defended, but almost no freight is shipped by the optimal schemes. Why? Simply because the transport organizations are given plans based on ton-kilometers. One can establish computer centers, and conceive superb algorithms, but nothing will come of it as long as the transport organizations reckon plan fulfillment in ton-kilometers.[1]

A deputy director of TsEMI has written that:

> The real saving from the introduction of the new methods has been considerably less than we expected. But this is not the fault of the officials in transport and it is not the fault of the models. Because of inadequacies in price formation, the minimization of costs leads to the worsening of practically all the indices of the work of motor transport. The same is observed in other fields.[2]

<u>Computers and the Management of Enterprises</u>

The problems noted by these writers are ones of goals and incentives. They arise from inherent limitations in the planning process and from the basic structuring of the Soviet economy. Despite the size and complexity

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[1] <u>Izvestiya</u>, December 4, 1964.

[2] <u>Discussions on Optimal Planning</u>, Proceedings of a Conference, compiled by L. Kazakevich and I. V. [illegible], 1968, 120-121.

of the planning system, it cannot possibly provide timely, detailed instructions for every product and every enterprise. Although managers operate within a restrictive web of regulations and constraints and are subject to the frequent intervention of Party and Government in the internal management of the enterprise, there remains much scope for managerial discretion and autonomy in day to day operations. This discretionary behavior is conditioned by a pattern of incentives, some of which have been explicitly planned, while others are unanticipated and, often, counterproductive. Excessive constraints, frequent intervention, and unanticipated incentives are, to the Western analyst, the major sources of lagging Soviet productivity. Given these conditions, the role of computers in revitalizing economic life is sharply limited.

One author,[1] in an excellent overview of the problems affecting technological progress in the USSR, notes three main directions in the attempted solution of these problems: (1) the reorientation of capital investment to foster modern and efficient technologies; (2) reduction in the time required to put modern plant and equipment into operation; and (3) devising new rules and incentives to encourage enterprises to adopt new technologies and produce new products.

The simplest use of computers is to replace labor by capital. Bookkeeping, payroll calculations, inventory management, and other such accounting chores have been the first use of computers in the Soviet Union, as they were in the United States. Indeed, some Soviet experts claim that these uses are about the only productive uses currently being made of the equipment. But more complex schemes have been planned. Automated management systems (ASU) are intended to automate the management of ministries and enterprises, to control production processes, and to both feed information to the automated planning system (ASPR--described above) and receive planning information from that system. ASU, though, has faced the same fate as ASPR. Little has been done to implement what many have thought to be an exceedingly grand and complex concept.

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[1] Gertrude Schroeder, "The Economic Reform as a Spur to Technological Progress in the USSR," Jarbuch der Wirtschaft Osteuropas, Vol. II, Günter Verlag, Munich, 1971, pp. 351-352.

These large-scale plans (ASPR and ASU), despite their failure of implementation, exemplify two of the three main thrusts of current developments. The aim here has been to promote the internal efficiency of planning and production processes and operating units within the context of the underlying structure. The leadership though has toyed with some potentially major reforms as represented by the Sovnarkhoz experiment, Libermanism, and the 1965 reforms. But each of these experiments has failed to provide any long term or meaningful change in economic life. The current attack on the problems involves seeking administrative solutions.[1] This has led to a burgeoning of the State's administrative apparatus, and a mass of new rules, regulations, plans, and indices that further constrain and complicate the life of a manager.

The very problems that computers are intended to ameliorate, however, have hindered the productive use of the computers themselves. More than machines are required. Software, programmers, maintenance engineers, and peripheral equipment are necessary before systems can even begin to operate. And the flexibility of management to reconfigure their organizations and processes in order to go beyond automated bookkeeping systems is a missing cornerstone of the whole endeavor. The Soviet system has not responded to these requirements for the reasons suggested above: excessive constraints and misincentives that affect most aspects of Soviet economic life.

One can conclude from this brief review that neither through the planning process nor through improved management will computers and economic cybernetics bring major (or perhaps even discernible) changes to Soviet growth and productivity. The retarding forces are structural and strong and computer usage is inhibited in the same manner and by the same forces as other economic processes. However, it must be noted that the growth of analytical economics, in attempting to cope with the critical planning and managerial problems facing the Soviet Union, has completely changed the tone of economic debate.[2] Real problems are now being discussed

[1] Schroeder, op. cit., p. 352.

[2] For evidence of these changes, see any recent review of Soviet economics and planning techniques; for example, see: A. S. Becker and others, in Mathematics and Computers in Soviet Economic Planning, John P. Hardt, et al, (eds.), Yale University Press, New Haven, Connecticut, 1967.

and controversies over substantive issues of a Marxist economy are not being suppressed. A new generation of economists and politicians are grappling with these problems in a new light.[1] In the meantime, thousands of individuals have been trained in the new techniques and are to be found throughout the economy. Computers and computer analyses are also more widespread than previously, though not in the numbers or quality desired. And most importantly, modes of thinking that at one time made one liable to imprisonment or execution are now the commonplace of institutes, universities, government agencies, and production ministries.[2] Debates surrounding these new ways of thinking are aired in newspapers and magazines as well as in learned journals. Whether or not the ideas of economic cybernetics will be stymied in the future by Marxist dogma or whether practitioners of applied theory will clash with the primacy of the Party is a question for speculation.

It must be noted though that the growth of cybernetics has followed a dialectic observed elsewhere in the Soviet Union. The proclamation of large-scale, grandiose plans that are later scaled down, modified, and refined has been a demonstrated technique for mobilizing large amounts of resources and redirecting them in non-incremental ways when the Party has decided on a major new thrust.[3] An important aspect of the growth of economic cybernetics that has been noted with respect to other major Soviet

[1]The notion of scarcity prices, for example, originally came out of the models of mathematical economists, but have now filtered down (in a very diluted form) to the applied level as intended stimulants of new technology. Many academics, however, contend that these innovations do not go nearly far enough to make much of a difference. Schroeder, op. cit., p. 357.

[2]Departments of mathematical economics have been established since 1965 in both the Universities of Moscow and Leningrad, with several hundred students in each department. Their graduates can now be found throughout the country, especially in the planning organizations of the republics, ministries, and in Gosplan. The major research institute, TsEMI, and several of its newer colleagues now have professional staffs of about 1000 people each.

[3]This is seen, for instance, in avaiation where the Party intervened in a major way to influence the development of jet-powered aircraft and to revamp the structure of civil air transport. See, Arthur J. Alexander, R&D in Soviet Aviation, R-589-PR, The Rand Corporation, 1970, p. 27.

decisions is that if the leadership values an end highly enough, or perceives a problem as being critical, they will step into the situation in a nonbureaucratic way, bringing personal, direct, high-level attention to the subject. I suspect that the continued high-level effort that would be required to solve the problems of efficiency and growth in the Soviet Union, and the probable direct clash with traditional values that the solution entails (in the form of radical decentralization) will result in little observed change in Soviet economic behavior or performance for the next decade, despite the availability or nonavailability of computer hardware. But beyond that, I can only note that so many new concepts are now at loose that longer term prediction is unwarranted.

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PRIVILEGED INFORMATION

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WN-8388-ARPA/CIEP

August 1973

THE COMPUTER GAP AND NATIONAL SECURITY: SOME IMPLICATIONS FOR RELAXING EXPORT CONTROLS (U)

Rein Turn

25X1

A WORKING NOTE
prepared for the

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY/
COUNCIL ON INTERNATIONAL ECONOMIC POLICY

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Nature of Privileged Information and location in document Intelligence information on Soviet computer technology located throughout the document.

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PREFACE

(U) The export of Western digital computers to Soviet bloc nations is subject at present to strict controls. The rationale for this policy is to protect a technological lead which the United States enjoys over the Soviets, and which provides the United States with a strategic military advantage. The strategic value of U.S. computer superiority derives from the size of our lead and the degree to which it is exploited in military systems--issues addressed in this Note. The same issues were discussed in another connection by Rein Turn for a Rand study in 1971 [17], and the present paper draws heavily on the previous one. While the present version uses revised and updated information, it also makes extensive use of the earlier work. Where references are still made to data cited in the earlier paper, we believe these data to be the best available.

(U) This Working Note is a part of Rand's on-going research for the Defense Advanced Research Projects Agency on international technology exchange, and for the Council on International Economic Policy dealing with computer export problems.

SUMMARY

(U) The United States currently possesses a strong lead over the Soviet Union in all aspects of computer technology--general-purpose and aerospace computer hardware, software (programming languages, operating systems, application programs), and large civilian and military systems. This lead can be expected to continue for the next five to ten years, despite Soviet efforts to increase their domestic computer production and import equipment, software, and know-how.

(U) Current computer applications in U.S. strategic systems do not fully utilize available advanced computer technology. Indeed, the currently most powerful Soviet computer, the BESM-6, appears capable of performing all the computing tasks needed by the Soviets to match (or counter) the advantages provided by existing U.S. systems. A cursory comparison of the weapon systems of the two countries reveals no instances where the United States has a significant advantage denied the Soviets because of their lack of adequate computer technology.

(S) A number of potential applications of advanced computer technology in strategic systems appear to exist, e.g., sensor data processing, real time ICBM retargeting in limited strategic operations, R.V. guidance and control, ABM data processing, and computer-communications networks. These applications require computer technology not available to the Soviets in the next five to ten years. It is not clear which among these applications will prove cost-effective and will therefore become operational in the United States. Although some of these applications are already being explored, as yet there has been no deliberate, systematic effort to fully utilize U.S. computer superiority.

(S) The COCOM export controls apply to commercially available, general purpose computers. Among the planned and merely suggested military applications for the most advanced computer technology, advanced general purpose machines would be necessary for only ABM data processing and computer communications networks. Other advanced technology applications demand special purpose computers or could be satisfied with less than advanced general purpose machines. Advanced general-purpose computers will be necessary for monitoring sensor collected data in ASW,

automated battlefields and satellite based surveillance systems, but they would not be sufficient for deployment of these systems because the required sensor technology will probably be unavailable to the Soviets in the next five to ten years. Thus, relaxing controls on export of general purpose computers could enable the Soviets to develop no more than a few of those advanced strategic computer systems presently unattainable to them. End-use controls may be able to prevent these applications. Whether the Soviets would choose to develop an ABM system or a computer-communications network, even if the necessary computing power were available, are separate and moot questions.

CONTENTS

I. INTRODUCTION

(U) The Council on International Economic Policy, and other agencies, are currently reviewing the COCOM restrictions covering the export of general purpose computers to Communist countries. Relaxing these restrictions would enable the Soviets to narrow whatever lead the US currently possesses in computer technology and capability. To best understand the repercussions of such relaxation on US national security, it is useful to assess the magnitude of US computer superiority, and to evaluate the strategic importance of this lead in the present and projected into the future.

(U) This Working Note presents an overview of the magnitude of the "computer gap," Soviet efforts to close that gap, the extent that superior computer technology has contributed to present US strategic capabilities, and the possible future value of the computer gap for US strategic posture vis-a-vis the Soviet Union. The aim of the discussion is to uncover the strategic implications of greatly increased exports of general purpose computers to Communist countries.

II. COMPUTER TECHNOLOGY: U.S. VERSUS SOVIET UNION (U)

ASSESSING THE COMPUTER GAP (U)

(U) It is usually difficult to compare two countries in a selected technological area. The problem is further compounded if one of the countries is a closed society, such as the Soviet Union, and if the technological area has great military and strategic importance, such as computer technology. In this case, the comparisons must be based on whatever information can be obtained from translations of the Soviet open literature, estimates by Western computer specialists, and classified intelligence documents. This Working Note draws on all three sources. It updates much of the information contained in a 1971 draft [17].

(U) One approach to estimating the state of computer technology is to consider the number of installed computers, installation growth rates, computational capabilities of computer systems, application areas (especially for military purposes), sophistication of the software (programming systems), and the apparent magnitude of the current research effort in computer sciences.

1973 Computer Census (U)

(U) The Soviets have never released official statistics of their computer population. However, Western observers have occasionally estimated the probable number of installed Soviet computers. The latest such exercise has a January 1973 cut-off date:

Area	Number of Digital Computers
United States	107,000 (58,000 general purpose)
Soviet Union	6,500-12,000
Western Europe and Canada	40,000
Germany	9,200
Britain	8,600
France	8,300
Japan	12,000
Eastern Europe	1,500-1,800

SOURCE: International Data Corporation.

(U) Among the 107,000 computers installed in the United States, the U.S. Government owns or operated (as of June 30, 1972) 6731 machines, 4800 of which were general purpose computers. A breakdown by agency of U.S. government-operated general-purpose computers (excluding computers used directly in weapon systems and in classified facilities) is presented below [11]:

Agency	Number of Computers June 30 1970	June 30 1971	June 30 1972
Air Force	1210	1271	1419
Army	927	949	968
Navy	894	1021	1137
Other	168	174	209
Total Department of Defense	3199	3415	3733
Atomic Energy Commission	754	954	1148
NASA	692	812	934
Civilian Departments	632	780	916
Total U.S. Government	5277	5961	6731

(U) Figure 1 shows the growth in the total number of computers in the United States, the U.S. Government, the Defense Department, the Soviet Union, Western Europe and Japan.

Computing Power (U)

(U) The Soviet Union lags greatly in the total amount of available "computer power"--something that could be measured in terms of the number of operations per second that the country's entire computer population could perform working simultaneously.

(U) The most powerful Soviet computer, BESM-6 (announced in 1966), is capable of .8 Mips (millions of instructions/sec).[1] By comparison,

[1] Based on a single-address equivalent mix of five additions and one multiplication. References 8 and 16 list the characteristics of BESM-6 and other U.S. and Soviet computers.

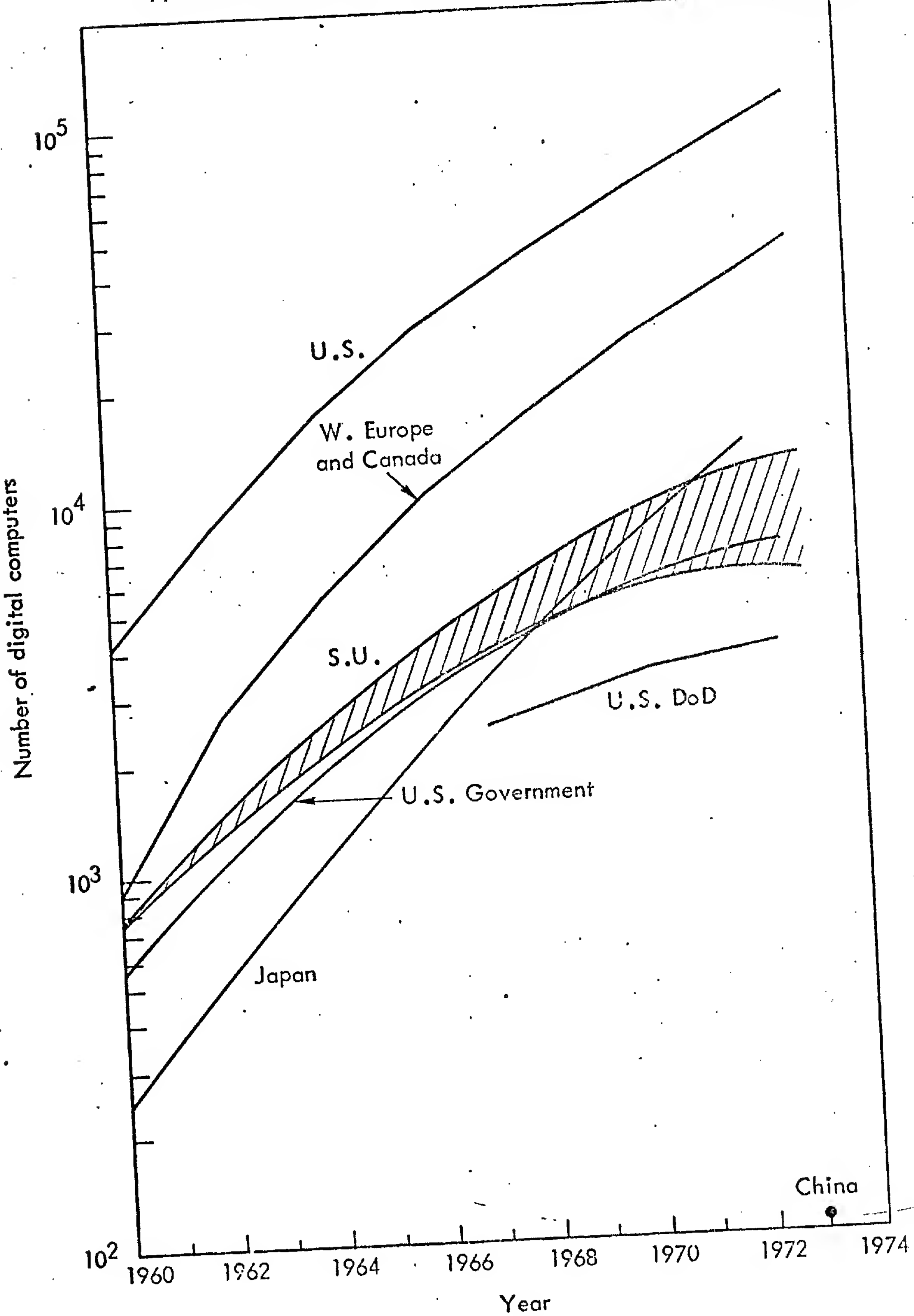

Fig. 1.— Estimated number of digital computers

the most powerful commercially available U.S. computer in operation, the CDC 7600 (announced in 1968), is capable of 17 Mips. Furthermore, the United States has some two dozen other computer types equivalent to or more capable than the BESM-6.

(U) The RYAD computer development effort of the East Bloc countries has finally led to operational systems (the R-10 through R-60, also called the ES-1010 through ES-1060, in steps of 10). The R-50, at nominal .5 Mips, is now the second most powerful Soviet computer. Also in the RYAD line, but not yet announced, is the R-60 which will have nominal capability in the 1.5-2 Mips range. This would make it 2-2.5 times the BESM-6 capability. Figure 2 depicts the historical development in speed of U.S. and Soviet computers.

(U) In addition to speed, the size and access time of the main memory system is an important parameter in determining computing capability. In this area, the Soviets used to lag even more than in computing speed, but they are now improving. The BESM-6 computer is equipped with only a magnetic core memory of 65,000 48-bit words; its access time is 2 μsec. By contrast, the CDC 7600 has a memory hierarchy of 65,000 60-bit words accessible in .0275 μsec and 512,000 words accessible in 1.76 μsec. The RYAD systems will narrow the high speed internal memory gap. The internal memories of R-50 and R-60 will be in the same general area as the U.S. computers of similar size. The planned R-60 will have a maximum of 2,048,000 8-bit bytes with a .5 second access time. Figure 3 depicts the present state of the memory gap.

(U) In the mass memory area, the Soviets recently achieved the capability of producing large capacity magnetic disc units. The RYAD disks form a family to match the different models. The R-50 has a disk unit of 290 megabits with a 90 ms. access time and a 1.3 megabits/sec. transfer rate. For comparison, a large U.S. disc drive, the IBM 3330, can store 6400 megabits, has a 30 msec. access time and a 6.4 megabit/sec. data transfer rate. Removable disc pack units are also in existence and in use with BESM-6 computers.

(U) Finally, an equally great technological gap exists in the area of computer input/output and mass memory devices. Many present types of

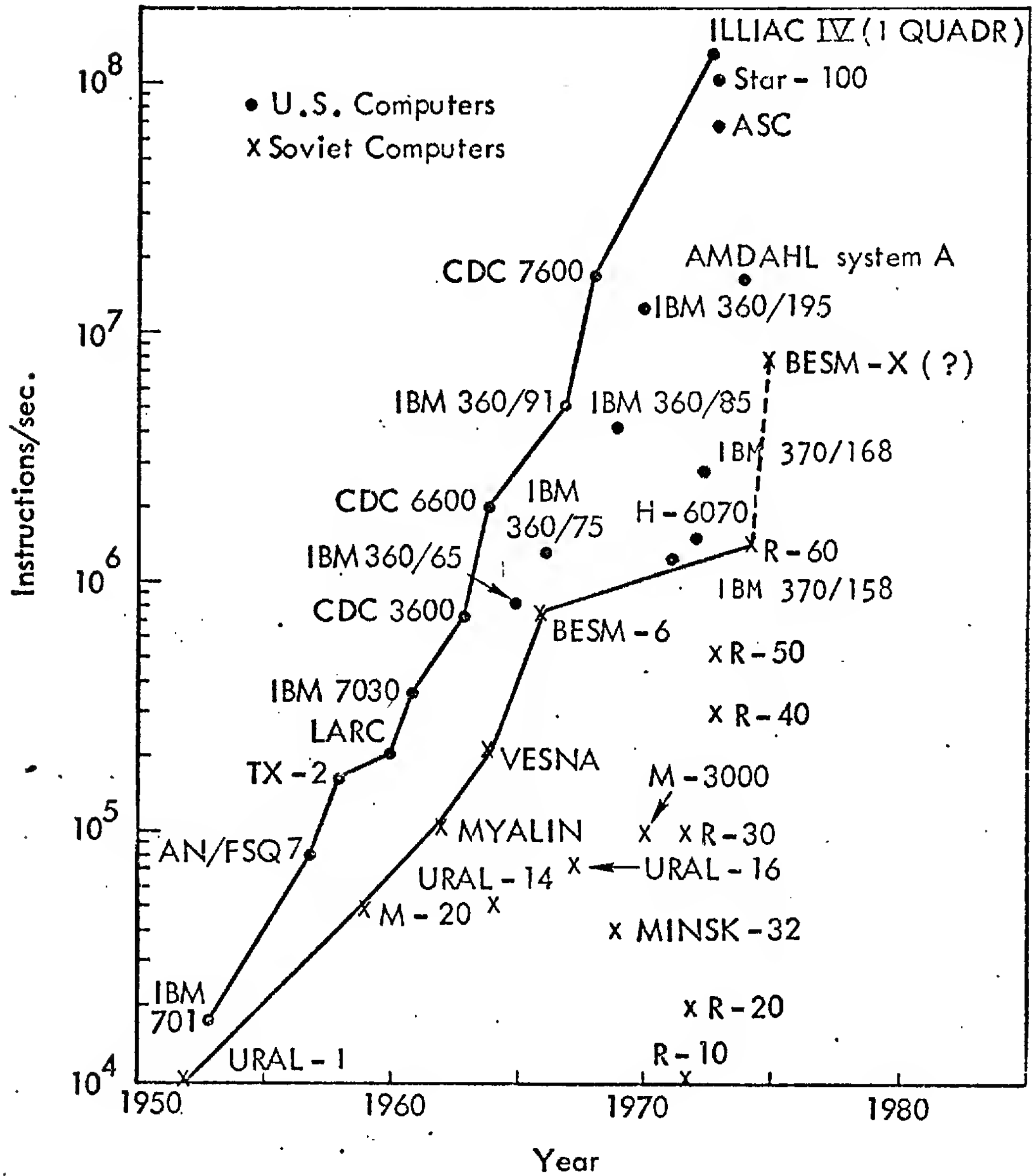

Fig. 2 — U.S. and S.U. computer capability*

*Comparing the computational power of computers is a most difficult task: the manufacturers' announced arithmetic operation times and storage cycle times are used to compare hardware capabilities, but are not very satisfactory. The operating system capabilities will greatly influence a system's performance, and also the type of problems being solved. Figure 2 is not suited for comparing the U.S. computers to each other, but only to show the computational regime of the U.S. computers versus the S.U. computers. The purpose is to underscore the magnitude of the "raw" computing capability gap. The information in Figure 2 comes from many sources which tend to present non-comparable data. For example, the estimates of BESM-6 computing capabilities vary from 0.5 MIPS to 1.0 MIPS. Similar differences in estimates occur for the U.S. computers.

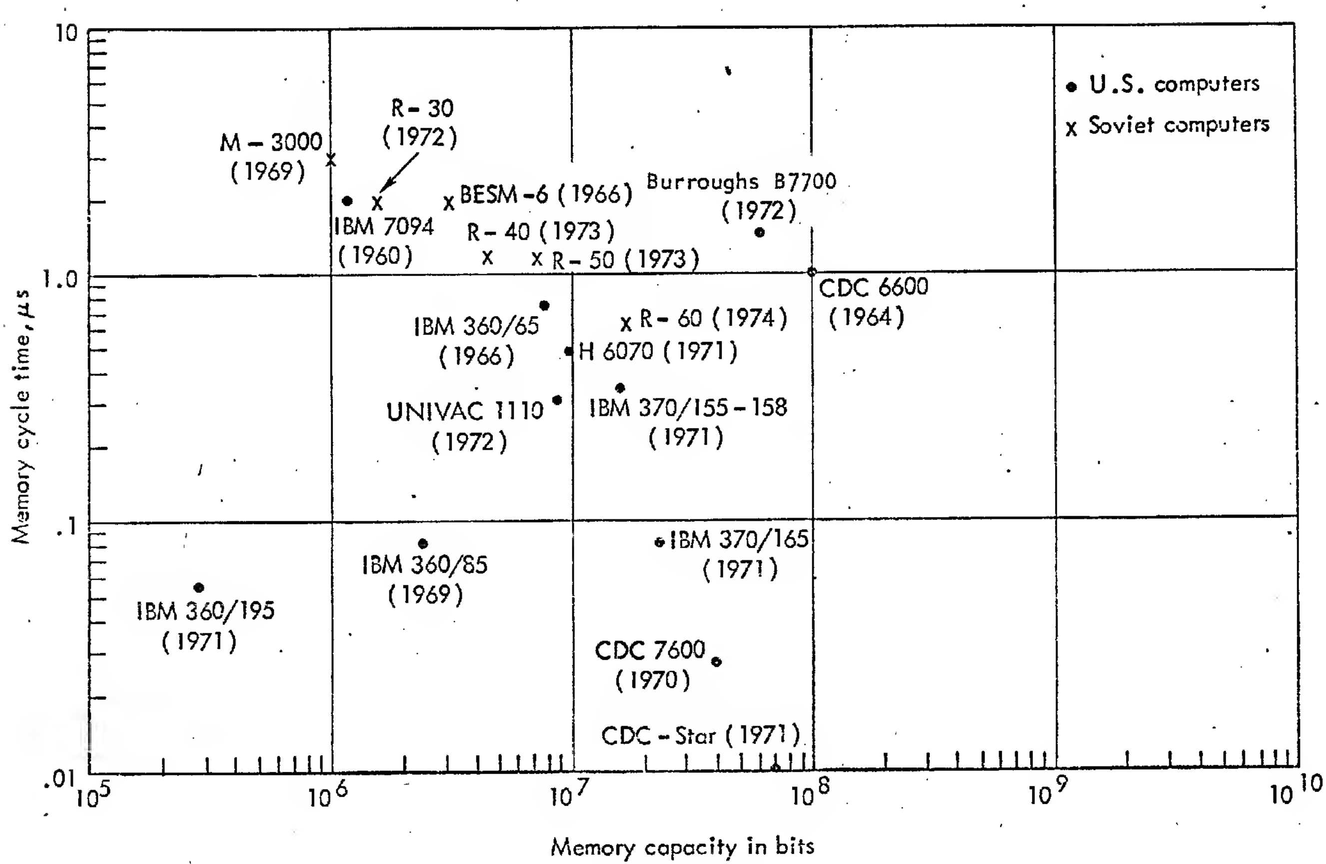

Fig. 3 — Comparison of computer memories

Soviet computers still use paper tape input and output. Only recently have reasonably reliable punched card readers, card punches, and line printers been developed. The RYAD computers will have a printer capable of 800-900 lines/minute and a card reader capable of 500 cards/minute.

Military and Aerospace Computers (U)

(u) Not much is known about S.U. military or space computers. A model, K-200, has been described as weighing 264 lbs., 9.3 ft^3 in size, and capable of 50,000 operations/sec. [16]. This compares favorably with the U.S. avionic computers. Incidentally, the space/military use of the K-200 has not been admitted by the Soviets.

(U) Some references have been made to the use of an onboard computer in the Luna 16 moon probe and in satellite tracking systems [15]. Also, a spaceborne computer was described to B. Boehm of The Rand Corporation during a 1971 trip to the Soviet Union [4]. The system was described as containing 4000 words of read-only memory in a unit about .1 cu. ft. in volume, and capable of .1 Mips. This computer compares quite favorably with advanced U.S. aerospace computers.

(S) U.S. intelligence information on Soviet military computers is very sparse. Indeed, a 1972 survey of Soviet computers [5] makes no mention of the aerospace computer reported by Boehm in 1971. Conjectures have also been made about the existence of a "hidden" Soviet military computer community [9]. Such a community may indeed exist for production of the various special-purpose computers for the Soviet military. However, the lack of information may also mean that onboard computers are not required; it is known that the Soviet approach to ICBM guidance and control is different from the U.S. approach. Furthermore, the use of simplified avionics systems in Soviet aircraft may not require onboard digital computers. Also lacking is information on possible large Soviet military computer systems for ABM defense, early warning, and command-control applications.

(U) By 1971, the United States had produced about 60 types of aerospace computers [2]. The situation has not changed considerably since that date. The emphasis has been on performance, reliability, and environmental hardness.

(U) A new development by the U.S. Navy, the AADC, will provide the U.S. military with a great leap forward in airborne computers--it is projected to be capable of providing the computing capability of the 360/195 in 1 cu. ft. of volume and at a cost of $30,000 (vs. the IBM 360/195 cost of $6,000,000) [7]. The AADC will use advanced large scale integration techniques as well as advanced semiconductor and magnetic components. The S.U. cannot be expected to achieve similar capability for at least 5-6 years.

Software and Computing Theory (U)

(U) In the area of computer programming languages and computer operating systems, the Soviets have chosen to rely mainly on U.S.-designed or internationally developed programming languages, such as FORTRAN, ALGOL, COBOL, and others. These are widely used in the Western world, and it is only natural for the Soviets to take advantage of these developments to save a great deal of development effort.

(U) The Soviets lag considerably in multiprogramming and time-sharing uses of computers. Until recently, one problem was the lack of fast mass memories. It is likely that similar difficulties are encountered in real-time applications of computers. It is well known that the programming task is one of the main difficulties in designing large U.S. military command and control systems. The Soviets may be expected to find this problem at least as difficult.

(U) In the theoretical aspect of computer design the Soviets have been lagging behind U.S. capabilities. A detailed U.S. survey in 1964 [12] concluded that the technical content of the majority of Soviet publications in the logic design of digital computers was somewhat behind U.S. standards. This situation still prevails in 1973. Exceptions have been 10 to 12 leading Soviet computer scientists who, as can be expected, have been the leading designers of computing and programming systems. (The "master designer" approach characteristic of the Soviet aircraft industry seems also to be emerging in the Soviet computer industry.) Theoretical developments from the Western world are easily transferred to the Soviets and, given their traditional mathematical-logical strength, there is no reason to believe that theoretical questions will significantly hinder Soviet computer development.

SOVIET EFFORTS TO NARROW THE U.S. LEAD (U)

(U) The Soviets are making considerable efforts to reduce the computer gap. Their admitted computing need is especially great in the area of economic planning and control, where a large network of some 2000 regional computer centers is planned to be introduced [19]. Automation of the manufacturing and processing industries is equally high on the agenda.

(U) The Soviet effort to overcome the computer shortage is being pursued on several fronts: designing new domestic computers, increasing domestic computer production, importing Western computers, negotiating licensing agreements to allow Soviet manufacture of Western equipment, and monitoring Western technical literature and trade shows. The probable Soviet capabilities in these areas and the effects on the U.S. computer superiority are briefly discussed below.

New Soviet Computers (U)

(U) Since the installation of the first BESM-6 in 1966, the Soviets have not announced any higher-performance computers. Beginning to emerge, however, are the RYAD computers, the result of a concerted effort by the Soviet Union and the Eastern European bloc countries to produce a series of third-generation computers similar to, and compatible with, the IBM System 360 computers [3, 4, 16]. The largest planned RYAD computer may achieve the 2-Mips category, twice the speed of the BESM-6. The RYAD development was first hinted at in 1967, with plans of first installations in 1969. This deadline was not met and only now are the R-10, R-20, R-40 and R-50 becoming available.

(U) The designers of the BESM-6 are reported to be engaged in a different project. BESM-6 was a 50-fold speed increase over BESM-4; thus, the new "BESM-X" could be expected to be much more powerful than the BESM-6, possibly attempting to reach the performance level of the CDC 7600. The latter was constructed from discrete high-speed transistors. Hence, Soviet lags in integrated circuit technology may not be a barrier to reaching CDC 7600 speeds.

(S) No significant information is available in the intelligence sources to permit confident prediction of the characteristics and initial

installation times of new Soviet computer systems. It is instructive to recall, however, that BESM-6 was announced in 1965--only a few months after intelligence sources and experts had predicted that a Soviet computer with BESM-6 characteristics was not likely before 1973 [9].

(U) Even if the Soviets manage to produce BESM-X with an 8-10-Mips capability in 1974, the commanding U.S. lead in extremely high-performance computers is not threatened. In the installation phase are the CDC STAR-100 with 100 Mips capability and the ILLIAC IV (one quadrant of 64 processor units) with 128 Mips capability. The new generation of U.S. computers is reported to be capable of direct execution of higher order languages--a great improvement from the user's point of view.

(U) Applications of laser technology permit very large and fast random access memories: a trillion-bit laser memory with 2.0 msec access time has been announced in the United States [18]. However, the Soviets are also actively pursuing laser applications to computing and may attempt to by-pass their difficulties in integrated circuit technology by concentrating on laser methods. Here, indeed, is a potential for the Soviets to greatly reduce the gap in computer and memory capability.

(U) In the area of aerospace computers, the premium is on size, power consumption, reliability, and ruggedness. These depend heavily on integrated circuit technology and high-quality manufacturing techniques. The Soviets can be expected to produce a few high-performance general-purpose aerospace computers in laboratories, but their serial production may be years off.

(U) To summarize, the performance gap will continue in favor of the United States both in very large computers and in aerospace computer systems. A great qualitative change is required in the Soviet industry before they can begin to catch up with the U.S. although eventually, of course, they will produce enough computers for their military and government needs.

Increased Soviet Computer Production (U)

(U) The Soviets are placing heavy emphasis on increasing computer production. For example, the 1971 state plan called for a 20 percent

production increase over 1970 levels. A 1971-75 plan expressed the goal of building 12,000-15,000 RYAD computers by 1975 [13]. The present Soviet computer production rate appears to be 750 to 1000 systems/year,[1] so it is highly unlikely that the 1975 objective can be reached, in two years.

(U) Furthermore, the Soviet computer manufacturing industry is reportedly beset with serious quality control and management problems [3]. The United States can be expected to continue holding a large lead in installed computer systems for the next five to ten years.

Export Controls (U)

(U) The Soviets apparently realize that their domestic production cannot satisfy computer needs, and they have increased their efforts to import high-performance computer systems from Western countries. The principal hindrance to the Soviets here is the U.S. and COCOM (Coordinating Committee of representatives of 14 NATO countries and Japan) countries' embargo on exporting strategic goods to Communist bloc countries. All export applications are closely scrutinized by the U.S. Department of Commerce, DoD, CIA, AEC, and State Department, according to precise guidelines on computer and peripheral equipment capabilities. Were it not for this embargo, the computer gap might be eroded, if the Russians chose to computerize their economy and military as extensively as is done in the U.S. Restraining the Soviets would be their scarce supply of hard currency, and a reluctance to depend on Western hardware.

Licensing Agreements (U)

(U) Although a large-scale program by the Soviets to import Western computers could considerably improve their computing capabilities (at the expense of millions of dollars), it would be more important to the Soviet domestic computer industry to negotiate licensing agreements with Western industry. This would give the Soviets access to Western manufacturing

[1] Derived from Fig. 1.

techniques, tools, and know-how that are otherwise hard to acquire. If the Soviets are unable to negotiate such licensing arrangements, they can be expected to be constrained by production technology from producing large numbers of general purpose computers in the next few years. The 1971-75 plan for production of RYAD computers called for installation of 12,000 to 15,000 third generation computers by 1975. Now halfway through that period, the Soviets are far behind schedule, evidencing their difficulties.

(U) France and Japan have already licensed Communist bloc countries to produce transistors and computer system components [8]. The results of these actions are being reflected in the RYAD machines. The Soviet decision to copy IBM System 360 features in RYAD also shows their interest in taking advantage of U.S. experience and achieving a great advantage in importing any System 360 peripheral equipment that passes the embargo limits. Finally, the ability to utilize System 360 software and application programs is allowing the Soviets to pull off a really colossal coup in RYAD software development.

(U) In summary, importing computer systems, obtaining licensing agreements for domestic manufacture of Western equipment and components, and having free access to a great volume of Western computer literature will greatly help the development of Soviet computer capabilities. All this would not permit the Soviets to catch up with total U.S. computer capability even in the complete absence of export and licensing controls. But, lifting the controls would certainly improve Soviet computer designs and manufacturing methods.

III. STRATEGIC APPLICATION OF THE COMPUTER GAP (U)

(U) It is apparent from the statistics that the United States has enjoyed a commanding lead in computer technology ever since the beginning of the computer era. Much of the credit for this, especially in the 1950s and early 1960s, is due to U.S. Government sponsorship (the AEC and DoD, in particular. For example, in 1965 the government provided more than $300 million of the total computer R&D effort of some $600 [14]. In 1972 all government agencies spent $120 million for computer R&D, 60 percent of which was spent by the Department of Defense, whereas private industry sponsored an additional $1 billion of R&D. This section discusses the military and strategic advantage the United States has gained from this investment. Also surveyed are the future directions in which the military is already planning or only suggesting to use advanced computers. If national security is at issue, then the computer gap is only relevant insofar as it is or could be employed to strategic use. Although unrestricted exports may threaten U.S. computer superiority, it is the strategic advantage rather than the computer gap itself, whose loss could influence national security.

GENERAL EFFECTS OF COMPUTER SUPERIORITY (U)

(U) In general terms, the availability of more computer power permits the performance of a fixed amount of computations in less time or more computations in fixed time. The computing costs may be expected to be reduced and, as a result, effective application of computing power will permit more rapid achievement of specific goals, increased efficiency, reduced costs, and more efficient utilization of resources.

(U) However, there may also exist certain pitfalls and negative aspects to easy availability of computer power: a tendency in R&D to substitute careful thinking with computer-based trial and error methods, flooding the management with computer-generated reports and statistics, and regarding computerization as a cure for poor management.

(U) Whether or not a computer gap actually results in a strategically superior position for the country with superior computer technology is not a clear issue. An attempt is made below to assess U.S. military uses of computers and to determine whether there is any evidence that the United States has gained significant advantages over the Soviet Union through the use of computer technology.

COMPUTER GAP AND MILITARY SYSTEMS TO DATE (U)

(U) As of July 1972, the U.S. Government operated over 6800 general purpose computers for military, space, and nuclear research and weapons development use [11]. Of these, some 240 are equal to or more powerful than the BESM-6. The breakdown of these is as follows (a list by computer types is given in Reference [11]):

Agency	Number of Large Computers July 1970	Number of Large Computers July 1972	Total BESM-6 Equivalents July 1970	Total BESM-6 Equivalents July 1972
Department of Defense	75	158	106	190
Air Force	37	66		
Army	18	42		
Navy	20	27		
Atomic Energy Commission	34	37	145	153
NASA	37	36	62	56
Total	146	241	313	399

(U) "BESM-6 equivalence" is the ratio of U.S. computer speed to BESM-6 speed, both in Mips. The term is introduced to give an indication of the number of BESM-6s needed to get the same computational capability in terms of total instructions executed per second. This assumes that computers can be netted together without a penalty, which is not true. Indeed, it is likely that BESM-6 computers cannot be netted at all; they have not been built for this purpose. They would need to be extensively modified, and are then certain to suffer a great degradation in performance (perhaps 50 percent). The problem of coordinating will take more and more time as the number of parallel computers increases, and there will be an upper bound to computer capabilities that cannot be exceeded no matter how many computers are connected. Further, it is not always

possible to get the computing power of a large computer by using a network of smaller computers--often the problem is strictly serial (can be computed only on a single processor at a time).

(U) Since 1970 the U.S. computer power to be "matched" by BESM-6s has increased by 86--no doubt larger than the BESM-6 production. The other S.U. computers are not even candidates for matching these capabilities. The RYAD R-50 and R-60, however, will have a chance, but if they are designed along IBM 360 lines, then they are not designed for multiprocessing systems use and would suffer considerable performance degradation if hooked up.

(U) In addition to the general purpose computers described in the above table, special-purpose digital computers for guidance and navigation are part of the Minuteman and the Navy's Polaris/Poseidon weapon systems; such computers also support the avionics systems of most types of U.S. military aircraft.

(U) The following table describing U.S. Air Force computers as of July, 1970 exemplifies how Defense Department computers are allocated among various military uses.

Application	Number of Computers	Percent	Number Larger Than BESM-6	BESM-6 Equivalents for the Large Computers
Base and Hq. Management, Finance, Training	445	37	3	3.9
Logistics	329	27	4	9.2
Research and Development	183	15	25	32.5
Communications	167	14	2	2.3
Intelligence	51	4	1	10.0
Operational Warning, Command and Control	35	3	2	2.1
		100	37	60.0

(S) For comparison with the above table, intelligence sources describe installations of 33 BESM-6s, but this figure must be interpreted

only as a lower bound to the number actually in existence. The above information illuminates the fact that, despite the overwhelming U.S. superiority in number of computers and computer power, its exploitation in strategic and nonstrategic military systems is relatively modest. Specific application areas are considered below.

Operational Applications (Intelligence, Command and Control) (U)

(U) At present, the principal operational applications of computers in the Air Force are:

- NORAD 425L Combat Operations Center (two Philco 2000 systems, about .1 BESM-6 equivalents each); will be replaced by Honeywell H-6070s (2. BESM-6 equivalents each).
- SAC Automated Command and Control System (SACCS), formerly 465L (3 AN/FSQ-31s, about .2 BESM-6 equivalents each); will be replaced by H-6070s.
- SAGE Air Defense System (11 AN/FSQ-7s, about .1 BESM-6 equivalents each); will remain as is.
- SAC Planning and Operations (IBM 7090, IBM 360/44, IBM 360/50, UNIVAC 1108, 2.2 BESM-6 equivalents total); will be replaced by H-6070s.
- Military Airlift management (4 IBM 360/65 computers, 4 BESM-6 equivalents); will be replaced by 3 H-6070s.

Other services, Army, Navy, and Marine Corps, also employ command and control systems for their forces. The World Wide Military Command and Control (WWMCC) system, being developed, will integrate the various command and control systems.

(U) The above applications do not at present use numbers of computers or computer power that are out of reach for the Soviet military. But U.S. systems are being upgraded. For ICBM force targeting, the Soviets could use smaller computers and perform the task over a longer period of time. For early warning and air defense applications, the BESM-6 computers (or smaller computers used in multiprocessing configuration) may be adequate.

Weapon System Development (U)

(U) In R&D applications, the United States has a much greater pool of government and private computer power available than does the Soviet Union. However, it is not evident that Soviet weapon system development has greatly suffered from lack of computers or that the level of general Soviet R&D in weapon development-related fields is inferior.

(S) One comparison showed that as of 1969 the Soviets had developed more weapon system types than the United States [14]:

Weapon System Types	United States	Soviet Union
Ballistic missile systems (since 1957)	12 developed 10 deployed	18 developed 15 deployed
Fighter aircraft (since 1960)	2 developed	9 developed
Tactical missiles (since 1960)	1 developed	5 developed
Aerodynamic missiles (since 1960)	8 developed	15 developed
Submarines (since 1960)	6 developed	11 developed

(U) Considerable use of computers is made in the design of modern aircraft. For example, the design of the Lockheed C5-A, during the period January 1965 to June 1968, required about 31,800 hrs. of computer time [5]. The machines used, however, were two IBM 7094s (.5 BESM-6 equivalents each) for the first 2.5 years, and then also a UNIVAC 1108 (1.1 BESM-6 equivalent). Hence, currently available Soviet computing equipment would not preclude performing computations for designing advanced aircraft.

Nuclear Weapons Design and Testing (U)

(S) Nuclear weapons design and processing of test data require large amounts of computation. On the average, the computations associated with a single underground nuclear test consume more than 1000 hrs. of computation on the CDC 6600 computers (2.5 BESM-6 equivalents).

This could be converted to 2500 hrs. of computation on a BESM-6 (which, actually, is rather generous in view of the limited storage capacity of BESM-6 systems). On the other hand, it is difficult to say how much of the 1000 hours of CDC 6600 time was really essential to the major test objectives. Since 1964, the United States performed an average of 45 underground tests per year, while the Soviet testing rate was 16 tests per year--perhaps reflecting their lack of computing support.

<u>ABM Defense Applications (U)</u>

(U) The ABM defense applications of computers--managing netted phased array radar beam; discriminating decoys, chaff, and booster fragments from warheads; and controlling interceptors--are among the most taxing tasks for digital computers. In addition, very large and complex computer programs are required.

(U) Deployment of ABM systems is constrained by the recent SALT agreements, but development of fixed site ABM systems is not so proscribed. Thus ABM development is still active and still represents a strategically important application of advanced computer technology.

(S) The United States does not have an operational ABM system, but prototypes of the required radars, interceptors, and computer system have been produced and successfully tested. An early version of the computer system--the Nike-X computer--is capable of 3 Mips (4 BESM-6 equivalents). More advanced (40-50 Mips) computers are being designed. The Soviets, however, have already deployed an ABM system around Moscow. Since the capabilities of this system are not known, it is difficult to speculate whether or not the Soviets have adequate computing support for this system. However, the system may be able to handle a relatively small U.S. threat with a netted BESM-6 configuration augmented by special-purpose processors.

(S) The intelligence community has generally attributed to the Soviets the computer capability to perform ABM computations [5]. This is usually done on the basis of taking the most powerful Soviet computer and postulating a sufficiently large multicomputer system. Whether this approach really produces valid estimates is questionable considering the U.S. multiprocessing experience; this may be an appropriate topic for further studies.

Some additional material appears below in connection with the discussion of current weapons development issues.

Space Applications (U)

(U) In space exploration and utilization the United States has been confronted with several challenges from the Soviets: Sputnik in 1957, the first manned orbital flight in 1961, the FOBS in the late 1960s, and the remotely controlled exploration of the moon in 1971. This is the technology area in which the United States (NASA) employs large amounts of computer power--934 computers 36 of which constitute 56 BESM-6 equivalents. In this area the Soviets, indeed, do not seem constrained by the computer gap.

(U) On the other hand, U.S. computer power has supported manned lunar landings, design of large boosters, and development of geostationary satellites for weather forecasting, navigation, communications, and surveillance. The success of the planned Grand Tour interplanetary probe depends heavily on the development of an extremely reliable spaceborne computer.

Summary (U)

(U) Although it seems that the Soviets have been able to acquire weapon systems to give them capabilities similar to ours in strategic offensive weapon systems and even more, this is not to say that the Soviets don't need more computers and advanced computer technology in their military forces.

(U) They would need advanced computers--beyond their present capabilities--for almost any strategic defensive system: ABM, ASW, space surveillance, satellite inspection, etc. These systems are not only characterized by advanced hardware, but also by very complex software. This is the overwhelming problem with similar U.S. systems and is likely to be equally great with the Soviets. The computers for these systems must have real-time operation capabilities and have facilities for accepting data from external sources over communication lines. For reliability, such computer systems must be operated as multiprocessor systems. The WWMCCS computers, Honeywell H6070/6080s, are of this class. On the other hand, the Soviet Union may get by without these systems if they assume that the U.S. will not be aggressively inclined in the future.

(U) The Soviet Union maintains far more men under arms than the U.S., and they are distributed over a larger geographic area. The Soviets have large stocks of military equipment, so supply and maintenance problems must be great. The same must be true for their tactical air units. For example, in 1970 the U.S. Air Force used 27 percent of its computers in logistics activities. The Soviets could use many computers and data communication systems here.

(U) Greatly increased exports of general purpose computers could enable the Soviets to manage and supply their military forces more efficiently, though such improvements would probably not have a substantial strategic impact. Most general purpose computers currently available in the West would not be directly suitable for strategic defensive systems because they lack the necessary real time capabilities and facilities for accepting data from remote sources over communications lines. In any case, on-site inspection would provide reasonable assurances that such computers were not connected into multiprocessor networks.

The Potential for Future Strategic Application of the Computer Gap (U)

(U) The United States has acquired technology for the development of computationally powerful, nuclear-effects hardened aerospace computers, as well as extremely high-performance ground-based or airborne computers. These provide a potential for developing military systems where these characteristics are essential and cannot be rapidly matched by the Soviets through the use of other technologies or approaches. Also, the United States has learned to use computer technology in complex weapon and command-control systems, and has developed techniques for successfully managing and bringing to completion large, complex development programs--Minuteman, Polaris/Poseidon, Apollo, and the L-systems. Especially valuable has been the experience in managing the production of the large computer programs required for the operation of these systems. As a result, the U.S. has the computer capacity to react to new strategic threats by the S.U. (or other countries for that matter). The S.U. is unlikely to have acquired similar computational capability to mount large scale crash efforts in advanced technology.

(U) The strategic systems that can provide more than a transient strategic advantage through their use of computer technology can be expected to utilize some of the extremes in computer hardware characteristics (computers with average characteristics are now or soon will be available for Soviet military systems) as well as very complex software. The hardware characteristics include:

- *Small* physical size, weight, and power consumption, yet large computing power: e.g., research to produce a 2 million operations/sec computer on a 3-in. diameter silicon wafer is being pursued by the U.S. Navy [7].
- *Fast*: general-purpose computers capable of 800-1000 Mips are predicted for the 1980s (see Fig. 2).
- *Large and fast memories*: trillion-bit memories accessible in 2.0 msec are in production.
- *Reliable*: redundant circuitry, automatic diagnosing and self-repair providing a 10-year unattended operating capability is being developed for the NASA Grand Tour computer [1].
- *Environmental hardness*: research to harden computers against nuclear effects is being pursued vigorously. Ruggedizing of computers is being pursued.
- *High-speed data communication*: laser data communication systems capable of 1000 megabits/sec are feasible.

(U) In all the above areas the United States now has a four- to five-year lead and is continuing vigorous research that promises to maintain, if not increase, the lead over the Soviet Union.

Current Efforts (U)

(U) A number of strategic systems currently in the study, development, or acquisition phase utilize advanced computer technology. The objectives of some of these programs are discussed below.

(S) Improving Existing Command-Control Systems. The Air Force is currently modernizing its fairly old command and control computer systems. The following list summarizes some of the improvements presently underway:

- The SAC command-control system will be enlarged (projects SATIN and SEED CUPS) to considerably increase the computing power to about 3 BESM-6 equivalents;
- The NORAD Combat Operations Center will be updated (project 427M) to about 10 times its former computing capability (about 2 BESM-6 equivalents);

- The Military Airlift Command is obtaining a large network of computers, MACIMS, for mission control and general management;
- The Logistics Command is designing a large management system, ALS;
- The Tactical Air Command is in the process of improving its command and control system (project SEEK FLEX);
- Computer-based tactical systems under study include UCNI (Unified Command, Navigation, and Identification), and PLRACTA (Position Location Reporting and Control of Tactical Aircraft).

Even though these innovations utilize advanced technology, the Russians could conceivably build adequately capable systems by nesting BESM-6 computers.

(S) Increasing Command-Control Survivability. The present approach to survivability of command-control systems is to provide airborne mobility. The AWACS system for air defense requires high-performance airborne computer capability in at least the .5-Mips range. The airborne command posts for SAC (the AABNCP) and the NCA (the NEACP) will require very high-performance onboard data processors if their functions also include sensor data processing and dynamic control of the forces--these requirements are a challenge to the current state-of-the-art airborne data processors (e.g., the IBM 4Pi-CC, with its .75-Mips speed, is equivalent to the BESM-6).

(S) Survivability of command-control systems appears to be equally important to the Soviets. Although it has been reported that they have already flown an AWACS-type aircraft, it is unlikely that they can match U.S. airborne computing capability. General purpose Western computers are poorly suited to airborne installation. Hence, their unrestricted export would not afford the Russians with airborne command and control capabilities.

(S) ABM Systems. The Safeguard and other Minuteman defense systems now being studied and/or designed require data-processing rates that can be met with existing highest-speed U.S. computers (CDC 7600, IBM 360/195). For possible future threats, the data-processing requirements may be in hundreds of Mips. However, even these could be met with the current trend in the development of U.S. computer technology. The Soviets, however, cannot be expected to achieve these computer speeds and, thus, to

field a general area defense ABM system in the same time frame. Limited systems, such as the present Moscow ABM system, which may be designed to counter relatively small threats, may be able to operate with the postulated advanced Soviet computers in the 2- to 8-Mips class (R-60 and BESM X).

(U) Indeed, ABM systems seem to represent the unique example among all the presently being pursued application areas mentioned above, that absolutely requires the advanced technological features embodied in the most advanced general purpose computers currently available. If CDC 7600s and IBM 360/195s are necessary and sufficient for ABM use, then a strong argument can be made for prohibiting their export to Soviet bloc countries. This is not to say that export of these computers is tantamount to furnishing the Russians with ABM capabilities. The Soviets probably have other critical technological deficiencies as well. This argument against export of these computers is weakened 1) to the degree that the SALT agreements effectively prohibit ABM development, and 2) to the degree that end-use guarantees can assure that these computers will not be wired to support an ABM system.

Suggested Future Systems (U)

(U) In a number of ways, computer technology could achieve a strategic advantage for the United States in the sense of increased survivability, effectiveness, and flexibility of offensive, defensive, surveillance, and command-control systems. Most of the suggestions below have been thought of previously and appear to be technically feasible for U.S. computer technology. However, they tend to be very costly, may not be cost effective in terms of strategic advantages, and therefore might never become operational.

(U) Onboard Computer in the Reentry Vehicle (RV). Such a computer must be extremely small in volume, weight, and power consumption. It must be extremely rugged, nuclear-effects hardened, and reliable, but not very costly. In association with appropriate sensors and flight control, it could be used for mid-course and terminal guidance to improve accuracy, and for active electronic counter measures and maneuvering to improve penetration of enemy defenses.

(U) Present trends in U.S. computer technology could produce such computers within the next few years. The associated sensors may present a more difficult problem. To counter U.S. RVs of this type, the Soviets would have to develop much more capable ABM systems requiring computers at least two orders of magnitude faster than the BESM-6. Production of onboard RV computers by the Soviets seems unlikely during the 1970s.

(S) Spaceborne Surveillance Computer Systems. Satellite-based surveillance systems that can resolve and filter out from the background clutter moving objects the size of ships, aircraft, mobile ICBMs, or IRBMs--or even tanks and trucks--could provide reconnaissance and intelligence information about Soviet activities. Such information could be used for strategic and/or tactical warning, to obtain enemy order-of-battle information, and for ASW purposes. The latter could be greatly improved by systems that could, for example, detect the wake of a submarine.

(U) The tremendous amount of data generated by such systems would make processing on board the satellite desirable. It might be necessary to do almost all clutter removal operations, and perhaps even maintain target files, on board. The speed and storage size requirements of such a spaceborne computer may greatly exceed those of currently planned surveillance systems. U.S. computer hardware technology should be able to meet these requirements, but development of the necessary algorithms and programs can be expected to be an extremely difficult task.

(U) The Soviets could use similar capability for monitoring U.S. strategic bombers, ships, submarines, airborne command posts, and possible future mobile ICBMs. However, they are not likely to develop reliable spaceborne computers in this decade.

(S) Sensor-Contained Computers. The United States has already used fields of emplaced sensors in Southeast Asia to detect moving enemy vehicles and troops (Project IGLOO WHITE). The advanced miniaturization techniques in computers would allow production of sufficiently rugged, capable, and inexpensive computers to permit their large-scale use in nonretrievable (as well as retrievable) sensors. The sensors could be used (1) to detect targets in tactical warfare situations, (2) to detect intrusion to military

sites, (3) in ASW sensors in oceans, or (4) in Remotely Piloted Vehicles (RPV). In the latter applications some of the sensor-related characteristics, such as extremely small size and low power consumption, may not be critical. Such sensor-contained computers could be used to perform signature analysis and discrimination functions, as well as applying counter-ECM transformations to the data communications. The United States should be capable of building these systems in a few years. Soviet technology cannot be expected to provide sophisticated sensor-contained computers in the near future.

(U) Antisubmarine Warfare. Both airborne and earthbound computers are used for processing sensor collected data in ASW. Advanced general purpose computers might be required for this purpose but ASW capability is constrained by sensor technology. Sensor technology is still in the development stage in the U.S. and the Soviets cannot be expected to have operational ASW sensors in the next five to ten years [20].

(S) High-Performance Airborne Computers. Airborne computer technology in the United States has mainly been concerned with avionics and fire control. However, much higher-performance airborne computers than currently required could be produced for use in large aircraft to increase the capabilities of currently planned U.S. systems, such as AWACS, airborne control posts, airborne surveillance data-processing facilities, airborne RPV control facilities, and airborne ABM launchers. For example, with appropriate weapons and more capable airborne computers, the AWACS-type systems may be capable of intercepting standoff cruise missiles and IRBMs in the NATO area.

(U) Although the Soviets can also build airborne computers, their lag in integrated circuit technology will result in larger and heavier equipment, which will reduce the payload, range, and flight endurance of their airborne systems.

(U) All the above suggested future applications of computers require special purpose machines. In no case would general purpose computers be suitable for adaptation. Their export would not directly provide the Soviets with computer capabilities in these areas.

(U) Computer-Communication Networks. The first attempts to connect computers into networks are already under way in the United States. The ARPA network and the MACIMS system are examples. These use commercially available Honeywell H-6070 computers. Networks of computers--redundant, digital, secure communications and data bases--and large numbers of on-line terminals can provide systems for peacetime, crisis, and post-attack management of forces, resources, and intelligence data. A large-scale capacity for secure military communications is a particular need. With redundancy in connectivity, the system may be made survivable.

(U) Computer networks are priority items in the Soviet plan for developing and applying computer technology and would greatly contribute to the flexibility and survivability of their command-control system. The Soviets are planning to overcome the telecommunications problems associated with this network by using imported equipment [3]. However, given the reported lack of reliability in their communication plant, error rates can be expected to greatly degrade the performance of any such network.

(U) Computer communications networks thus represent a second military application area (in addition to ABM support) for which advanced Western computers might be directly adapted. Most general purpose computers are not, however, designed for redundant parallel operation in a network of computers and external data sources. Modification would be required to install most imported computers in such a fashion, and in any case rudimentary end-use guarantees should be able to assure they are not so installed.

IV. CONCLUDING REMARKS

(U) It is clear that the United States leads the Soviet Union in number of installed computers (at least ten to one), speed of high-performance computers (at least one hundred to one), memories, peripherals, software, and all other components of computer technology. Despite Soviet efforts to improve domestic computers and to import equipment, software, and manufacturing technology, the U.S. lead will continue indefinitely. It may be expected, however, that by 1978 or 1979 Soviet computer technology will be at the current (1973) U.S. level and that they will have the capability to field systems similar to those currently in operational use by the U.S. military. If one goal of the U.S. military is to maintain a strategic advantage in the sense that the U.S. always manages to invent and deploy a new, more powerful weapon system, which provides deterrence for a while (say 5 years), then we certainly need a computer advantage. That is, we must be able to produce systems which will require the Soviets a number of years to counter or match. But this game gets more expensive all the time, and the Soviet computer capability is increasing steadily so that the time interval that the U.S. enjoys a superiority due to a new system is likely to decrease steadily. Application of export restrictions to U.S. and Western computing equipment and software will delay and increase the costs, but not prevent, the Soviet advances.

(U) The strategic advantage afforded the U.S. by its computer superiority is relatively modest. As a result, the risk of greatly increased exports of general purpose computers to East bloc nations is also only modest. Of the strategic application areas surveyed in this study, only ABM data processing and computer communications networks could greatly benefit from the technology of advanced general-purpose computers. Advanced general-purpose computers will be necessary for monitoring sensor collected data in ASW, automated battlefields and satellite based surveillance systems, but they would not be sufficient for deployment of these systems because the required sensor technology will probably be unavailable to the Soviets in the next five to ten years [20]. Sensor technology is still in the

development stage in the U.S. All other application areas either require special purpose computers or, if they use general purpose computers, do not absolutely require the speed and memory size of the advanced machines. SALT aside, it is not at all clear that the Soviets would be able to develop an effective ABM system or would try to for that matter, even if advanced computers were made available. The Soviets are pursuing their own program to develop a computer network for command and control operations, though it is experiencing difficulties. Rudimentary end-use guarantees should be able to assure that exported Western computers are not directly wired into either a computer network or an ABM system.

(U) A separate and important question not considered in this study is whether or not Western manufacturers should be allowed to license the Soviets to produce general purpose computers. Whether or not production technology gleaned from licensing arrangements would be valuable and transferable to production of special purpose computers of more strategic value, requires further study.

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